INDOOR AIR QUALITY ASSESSMENT

Department of Public Works
Customer Service Center and Garage
76 East Worcester Street
Worcester, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
October 2017

BACKGROUND

Building:	Department of Public Works (DPW) Customer Service Center (CSC) and Garage
Address:	76 East Worcester Street, Worcester
Assessment Contacts:	Matthew J. Labovites., Asst. Commissioner- Operations
Reason for Request:	Referred by Department of Labor Standards (DLS) regarding water damage and mold concerns
Date of Assessment:	9/28/2017
Massachusetts Department of Public Health/Bureau of Environmental Health (MDPH/BEH) Staff Conducting Assessment:	Jason Dustin, Environmental Analyst/Inspector, Indoor Air Quality (IAQ) Program
Date of Building Construction:	1950
Building Description:	Brick building formerly used as a warehouse
Building Population:	< 10 (in office area)
Windows:	Not openable

METHODS

Please refer to the IAQ Manual and appendices for methods, sampling procedures, and interpretation of results (MDPH, 2015).

RESULTS and DISCUSSION

The following is a summary of indoor air testing results (Table 1).

- ***Carbon dioxide*** levels were below 800 parts per million (ppm) in all areas surveyed, indicating adequate air exchange for the occupancy at the time of assessment.
- ***Temperature*** was within the MDPH recommended range of 70°F to 78°F in occupied areas.
- ***Relative humidity*** was within the MDPH recommended range of 40% to 60% in all areas.
- ***Carbon monoxide*** levels were non-detect (ND). The National Ambient Air Quality Standard (NAAQS) for carbon monoxide is 9 ppm over an 8-hour averaging time and 35 ppm over a 1-hour averaging time. The American Conference of Governmental Industrial

Hygienists (ACGIH) industrial (garage) guideline for carbon monoxide is 25 ppm. No vehicles were idling in the garage during air sampling.

- ***Particulate matter (PM2.5)*** were below the NAAQS of 35 $\mu g/m^3$ in all areas surveyed.
- ***Total Volatile Organic Compounds (TVOCs)*** levels were ND.

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 ppm in all areas surveyed. The office area utilizes an air handling unit (AHU) to introduce fresh air into the space. Conditioned air is ducted to the office areas and is distributed through supply diffusers which are located throughout the space (Picture 1). Stale air is brought back to the AHU through ceiling-mounted return vents (Picture 2).

The main garage area has several general exhaust fans (Picture 3) that are operated on an as-needed basis. There are make-up air supply ducts with louvred doors (Picture 4) to introduce fresh air during the operation of the exhaust fans. It was reported that DPW staff typically leave the garage doors open to further increase air circulation.

There did not appear to be any vehicle tailpipe exhaust capture system in place in the garage area. Of the materials produced by the process of combustion, carbon monoxide can produce immediate, acute health effects upon exposure. The US Environmental Protection Agency (US EPA) has established National Ambient Air Quality Standards (NAAQS) for exposure to carbon monoxide in outdoor air. Carbon monoxide levels in outdoor air must be maintained below 9 ppm over an 8-hour period and below 35 ppm over a 1-hour averaging period in order to meet this standard (US EPA, 2017). In an industrial setting (e.g., garages, warehouses, shipping/receiving) where carbon monoxide may be a normally occurring pollutant, several work place safety standards exist to reduce exposure. The National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL) for carbon monoxide is 35 ppm as an 8-hour TWA and 200 ppm as a ceiling (NIOSH, 1992). The American Conference of Governmental Industrial Hygienists (ACGIH) has a carbon monoxide threshold limit value (TLV) of 25 ppm as a TWA for an 8-hour workday and 40-hour workweek (ACGIH, 1994). As shown above, carbon monoxide was non-detect in the garage at the time of the assessment.

Measurement for airborne particulates in combination with carbon monoxide measurements were taken to identify combustion products. The combustion of fossil fuels can produce particulate matter that is of a small diameter (2.5 μm), which can penetrate into the lungs and subsequently cause irritation. For this reason, a device that can measure particulate matter of a diameter of 2.5 μm or less (PM2.5) was used to identify pollutant pathways from vehicles into occupied areas. As mentioned above, PM2.5 particulate measurements in the garage were below the NAAQS guideline of 35 $\mu g/m^3$.

Pathways

IAQ staff noted some pathways for vehicle exhaust and other pollutants (e.g. moisture, odors) to move from garage bays and unconditioned areas into adjacent office areas. Missing ceiling tiles and gaps around utilities were noted in the server room (Pictures 5 and 6). Further investigation of this separation wall should be conducted especially in areas above the ceiling tiles. If further pathways are found they should be properly sealed. As recommended by IAQ staff, the main door separating the garage and office area is reportedly kept closed (Picture 7). This door should be periodically inspected to ensure that weather stripping and door sweeps are intact so that no light is visible around the door edges.

Microbial/Moisture Concerns

In order for building materials to support mold growth, a source of water exposure is necessary. Factors to consider include:

- DPW garages are normally exposed to moisture from vehicles and activities;
- Most building materials in the garage section are made from materials that are *not* conducive to mold growth (e.g., brick walls and concrete flooring);
- At the time of the visit, porous items were not observed on floors inside the garage; items such as cardboard boxes were found elevated off of the floor or stored other ways. This is a good practice as porous items can become moistened garage activities or condensation, which can lead to water damage and mold growth;
- DPW staff reported that the roof was recently repaired after identifying water leaks at the intersection of the higher garage roof and the lower CSC roof.

IAQ staff identified multiple areas in the CSC office area with water-damaged materials. The server room had the most extensive water damage reportedly, from the water leak at the intersection of the garage/office roof levels (Pictures 8 to 10). DPW staff reported that this leak has since been repaired. This room has a ductless air conditioning unit which appeared to have an accumulation of debris in the supply vents (Picture 11). These units should be regularly cleaned to prevent debris from serving as a substrate for mold colonization should condensation occur. They should also be monitored to ensure that condensation generated is properly drained and not a source of moisture to the server room.

The CSC office area also had several walls in other areas which appeared to have a "ghosting" effect. The wall studs and nails were visibly stained at the surface of the gypsum wallboard (Pictures 12 and 13). The walls affected were primarily exterior walls located on the south side of the CSC (facing railroad tracks) and the interior walls which abut the garage. A small area of gypsum wallboard was also impacted in this manner in the break room near the refrigerator.

This ghosting effect is typically the result of either small particulate (e.g., soot) accumulation on surfaces of opposing electrical charge, or chronic moisture and microbial growth. Small particulates may result from an improperly functioning and vented furnace, or from indoor sources such as burning candles, which may emit both particulates and potentially irritating fragrances. It may also be accumulation of particles from vehicle exhaust from the garage area that have entered through pathways such as those described above.If the dark streaks are wiped with a wet towel and appear to smear on the surface then they are most likely the result of particulate accumulation. This can be cleaned to remove the streaking.

Sealing pathways to the office as recommended above will help to reduce any soot/particulates from vehicles entering from the garage which may also be a factor in producing this effect. DPW staff should also ensure that the filters in the AHUs are of proper efficiency (e.g., MERV 8 or better) to filter out particulates in the fresh air intake stream due to the industrial location of the CSC.

Chronic moisture may be the result of condensation on GW which is contact with an unconditioned space such as the outside or the wall of the garage via a thermally conducting material such as metal bracing or nails. If chronic moisture is suspected, the wall cavities should be inspected more thoroughly during unoccupied hours to ensure that hidden mold is not present.

Extensively moldy materials can not be cleaned and will need to be remediated in a manner consistent with recommendations found in the US EPA document, "Mold Remediation in Schools and Commercial Buildings" (USEPA, 2008).

There may be several factors contributing to chronic moisture at the CSC. As mentioned, the recently repaired roof leak at the intersection likely contributed to the significant water damage in the server room. The grading of the slope leading from the railroad tracks may be directing water towards the southern exterior brick wall. This location is also overgrown with vegetation and will hold moisture against the brickwork (Picture 14). Brick and mortar walls are not water-tight but typically have a drainage plane with a water-proof membrane behind the brick wall and functioning weep holes to allow drainage from the base of the brick (Figure 1). Also, before gypsum wall board is installed, insulation and a vapor barrier is generally required to resist accumulated moisture and condensation due to water vapor from penetrating into the wall board. IAQ staff have observed many different buildings where this is either not present or not installed correctly. This can not be verified without opening up walls to inspect for proper vapor barrier installation but may be contributing factor. The moisture content of these walls were checked with a moisture meter and found to be dry at the time of this assessment.

Other concerns

IAQ staff noted the presence of bait stations and sticky traps throughout the office area. In any pest elimination strategy, it is important to not only bait or trap rodents that get into the building but also seal any pathways, remove areas of harborage, and eliminate food sources. The MDPH recommends the implementation of an Integrated Pest Management (IPM) plan in addition to traditional pest baiting/trapping methods to more effectively control pest issues. The IPM guideline can be found at: http://www.mass.gov/eea/docs/agr/pesticides/publications/ipm-kit-for-bldg-mgrs.pdf.

CONCLUSIONS and RECOMMENDATIONS

In view of the findings at the time of the visit, the following recommendations are made:

1. Continue to refrain from idling vehicles in the garage.
2. Utilize existing general exhaust ventilation whenever combustion-related activities are performed (e.g., vehicle emissions, welding, etc.).

3. Ensure adequate make-up air supply during the use of ventilation systems to effectively clear and eject products of combustion from the garage bays.
4. Continue to keep doors that separate garage bays from office areas closed. To prevent products of combustion from entering these occupant areas, maintain weather stripping and door sweeps as needed so that no light is visible beneath or around the doors.
5. Replace missing ceiling tiles and seal any other gaps or breaches in the shared walls and ceilings between occupant areas and garage bays to avoid the intrusion of particulate matter, odors, and water vapor into occupied areas.
6. Water-damaged gypsum wall board, ceiling tiles, paper-backed insulation, and carpeting should be removed in a manner consistent with the EPA guideline "Mold Remediation in Schools and Commercial Buildings" (USEPA, 2008).
7. Determine if the "ghosting" effect noted on the CSC walls is the result of surface soot accumulation or chronic moisture. Clean walls with mild detergent if soot/particulate accumualation is noted.
8. Inspect the wall cavities for proper insulation and vapor barrier while performing the removal of water-damaged building materials. Install insulation and vapor barrier if necessary before replacing the building materials.
9. Inspect the south-facing exterior perimeter for proper drainage. If necessary, install perimeter drainage to direct stormwater down and *away* from the building foundation/brick wall.
10. Consider consulting with a water intrusion contractor or building engineer to inspect the building envelope to eliminate any water/moisture/condensation issues which may exist (e.g., brick/mortar, drainage plane/weep holes, flashing, roof drainage/gutters, etc.).
11. Ensure that AHU filters are changed at least twice per year and that they are of proper efficiency (e.g., Pleated MERV 8 or better). Consult manufacturer recommendations to ensure correct filter selection.
12. Regularly clean the ductless air conditioning unit according to manufacturer recommendations to prevent the accumulation of debris. Ensure proper drainage of condensate from the unit.
13. Continue with pest control efforts at this facility and consider adopting an IPM plan for more effective pest elimination.

14. Trim or remove any vegetation within 5 feet of the building exterior to reduce moisture against building envelope.
15. Continue to store porous materials (e.g., cardboard boxes, paper items) on pallets or shelving to prevent water damage. Discard any existing water-damaged porous materials.
16. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritation).
17. Refer to resource manual and other related indoor air quality documents located on the MDPH's website for further building-wide evaluations and advice on maintaining public buildings. These documents are available at http://mass.gov/dph/iaq.

REFERENCES

ACGIH. 1994. Threshold limits values for chemical substances and physical agents and biological exposure indices for 1994-1995. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

Massachusetts Department of Public Health (MDPH). 2015. Indoor Air Quality Manual: Chapters I-III. Available at: http://www.mass.gov/eohhs/gov/departments/dph/programs/environmental-health/exposure-topics/iaq/iaq-manual/.

NIOSH. 1992. Recommendations for occupational safety and health: Compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 92-100.

US EPA. 2008. "Mold Remediation in Schools and Commercial Buildings". Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. September 2008. Available at: http://www.epa.gov/mold/mold-remediation-schools-and-commercial-buildings-guide.

US EPA. 2017. National Ambient Air Standards (NAAQS). US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. https://www.epa.gov/criteria-air-pollutants/naaqs-table.

Picture 1

Supply air diffuser

Picture 2

Return air grate

Picture 3

General exhaust fan in DPW garage

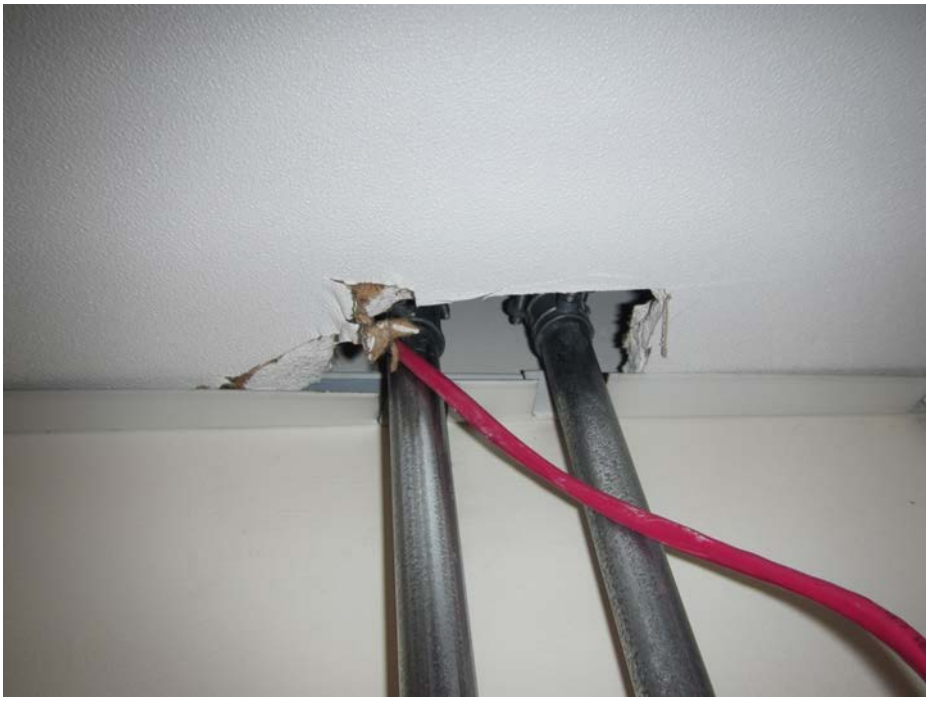
Picture 4

Make-up supply air vent

Picture 5

Missing ceiling tile in server room may serve as a pathway

Picture 6



Gaps around utilities in server room

Picture 7

Door leading from garage to office kept closed

Picture 8

Water-damaged gypsum wallboard in server room

Picture 9

Water-damaged ceiling tile in server room

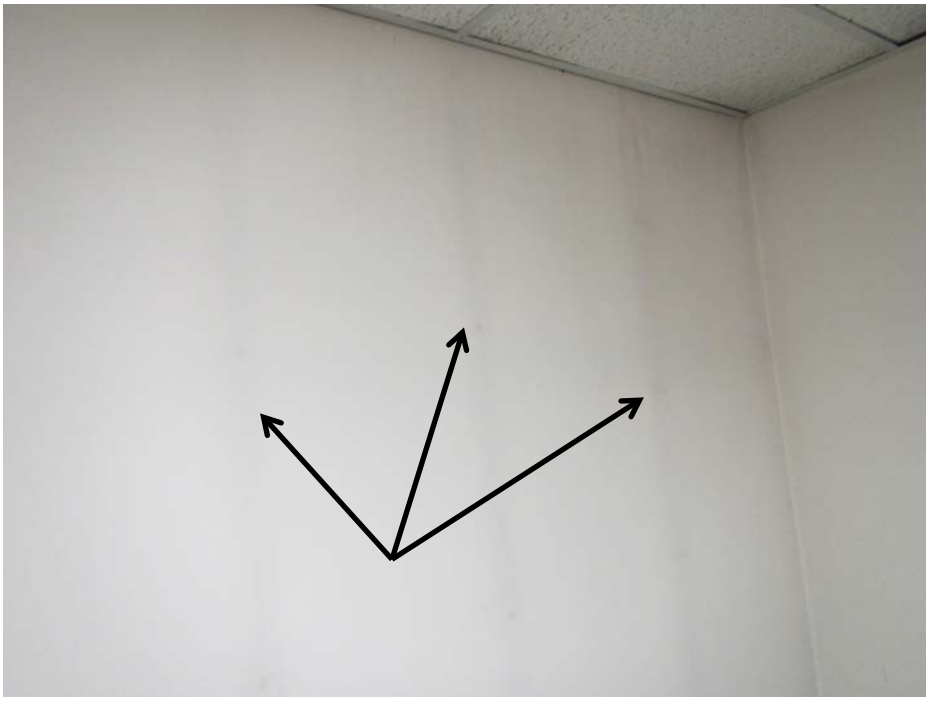
Picture 10

Water-damaged gypsum wall board in server room

Picture 11

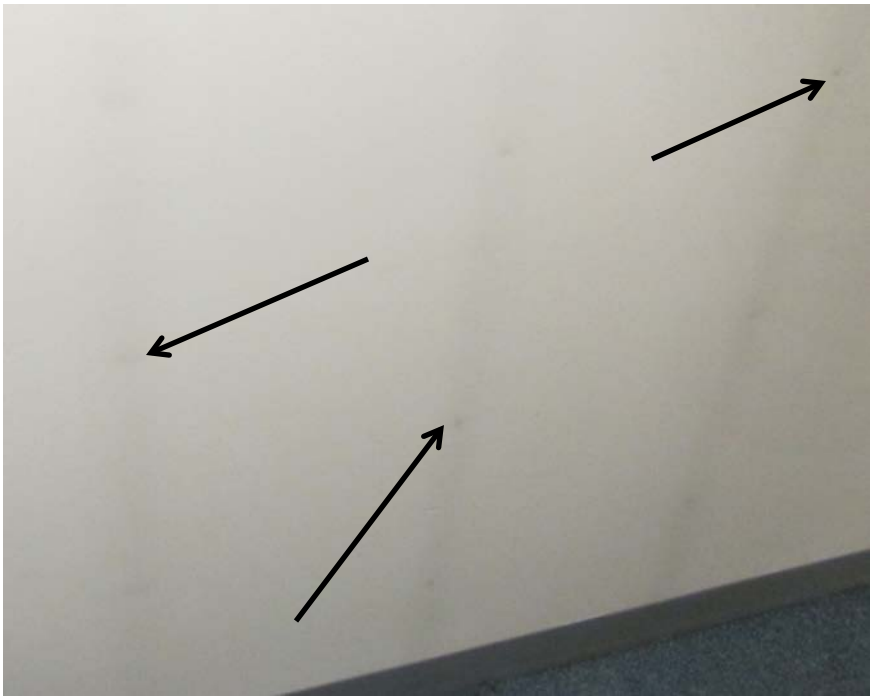
Air conditioning unit vent with debris accumulation in server room

Picture 12



“Ghosting” effect observed on walls in the CSC area

Picture 13



“Ghosting” effect on walls (note outline of studs and nails)

Picture 14

Grading from railroad tracks down to exterior of building (note overgrown vegetation)

Location: Worcester Department of Public Works (DPW) **Indoor Air Results**

Address: 76 East Worcester Street, Worcester **Date: 9/28/2017**

Table 1

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	TVOCs (ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background	337	ND	74	52	13	ND	-	-	-	-	Sunny, light wind, trucks idling in parking lot
Server Room	568	ND	73	51	9	ND	3	N	Y	Y	WD CTs, WD GW, roof reportedly repaired, ductless AC unit has debris, MT, CPs, HS, gaps around utilities
Main Office- east	670	ND	75	59	5	ND	5	N	Y	Y	WD CT, "ghosting" streaks on GW walls in rear hall & restrooms
Main Office-west	624	ND	76	55	4	ND	5	N	Y	Y	PC, HS, DEM, carpeting
Break room	547	ND	77	53	4	ND	0	N	Y	Y	WD CT x 1, small area of "ghosting" on GW wall near fridge
Conference	541	ND	77	40	8	ND	2	N	Y	Y	Carpeted
Office Manager	596	ND	75	41	5	ND	3	N	Y	Y	

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
AC = air conditioner
CPs = cleaning products
CT = ceiling tiles
DEM = dry erase materials
GW = gypsum wallboard
HS = hand sanitizer
MT = missing tiles
PC = photo copier
WD = water-damaged

Comfort Guidelines

Carbon Dioxide: < 800 ppm = preferred
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%